MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

Technical Problems of Welsh Agriculture

REPORT OF A COMMITTEE
APPOINTED BY
THE AGRICULTURAL IMPROVEMENT COUNCIL
FOR ENGLAND AND WALES

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AGRICULTURAL IMPROVEMENT COUNCIL
FOR ENGLAND AND WALES

Report of the Committee on Technical Problems of Welsh Agriculture

I. INTRODUCTION

1. We were appointed by the Agricultural Improvement Council at the request of the Minister in October 1956, with the following terms of reference:

> "To review the technical problems of agriculture in Wales and to advise whether there are any particular matters requiring further research to which the attention of the Agricultural Research Council and the Ministry should be invited."

2. We have held a number of meetings in London and toured mid and North Wales from 15th to 18th April 1957, and central and South Wales from 21st to 23rd April, 1958. We have taken evidence, either oral or written or both, from a number of selected farmers, Welsh organisations and officials; and have also had discussions with a number of officers in the Ministry both in the Principality and at Headquarters. A list of these witnesses is set out in Appendix I to our Report.

3. We have approached our task as agriculturists interested in practical problems and their scientific solution and have tried to identify problems of major importance in all aspects of Welsh farming. We have found no evidence that there are any major fundamental research problems which are peculiar to Wales alone. Many of the problems which have come to light are in the husbandry field; and many of them are, in varying degrees, problems in England and Scotland as well.

4. Having found a number of problems we have considered whether there is adequate information available that would solve or help to solve them or whether further knowledge is required.

5. We wish to make it clear that we have interested ourselves in all aspects of agriculture in Wales except the economic problems of the industry which we have considered to be outside our terms of reference.

6. We have examined the agriculture of both the lowland and highland areas of the Principality and whilst each has its problems, we have concluded *in the main* that those of the high land areas present the greater difficulties.

7. In our report we include only those problems that we consider to be important, and additionally in dealing with climate, topography and agricultural statistics, we include only the salient points, these topics having been dealt with very adequately in the past in a number of reports on Welsh Agriculture.

II. CLIMATE AND TOPOGRAPHY

8. Climate and topography exercise a dominant influence on farming in Wales. The land rises to 3,000 ft. on the western coast and is in the full face of the prevailing south-west winds. Only 41 per cent. of the land area

is below 500 ft., 32 per cent. lying between 500 ft.–1,000 ft., 20 per cent. between 1,000 ft.–1,500 ft., the remaining 7 per cent. being over 1,500 ft. The area is characterised by a central upland with mountain ranges and moorlands divided up by relatively fertile valley and coastal belts. The western coastal plain is very narrow and sometimes is non-existent. On the eastern side the valleys open out more widely. In some counties such as Brecon and Radnor between 50 and 60 per cent. of the land is above 1,000 ft. while in Merioneth, Montgomery and Denbigh, the proportions vary between 33 and 50 per cent. In remaining counties relatively less of the land is at these high elevations.

9. There is a high annual rainfall, about 45 per cent. of the Principality having more than 50 ins. Only a very small area, some 230 square miles out of 8,000, has under 30 ins.—about half the area which receives more than 80 ins. per year. Coupled with the high rainfall there is high air humidity and low insolation, the central core of the area having a mean daily duration of less than 4 hours. There are consequently areas where impeded drainage is a serious problem. The growing season is generally short in the higher parts of the area. There are other areas in the United Kingdom where similar conditions of rainfall, humidity and insolation obtain, e.g. some of the S.W. Counties, the Lake District and parts of Scotland.

III. AGRICULTURAL STATISTICS

10. Out of some 4·4 million acres some 2·6 million acres consist of crops and grass, and 1·8 million acres of rough grazings. The tillage acreage, which was 885,000 acres in 1943, continues to drop and in 1955 only some 423,000 acres of crops were grown. (The tillage acreage has also dropped in England.) Temporary grass, which was estimated at 290,000 in 1943, has risen steadily since the end of the war and is now estimated at 480,000 acres. Permanent grass, which was down to 1·38 million acres in 1943 as a result of the ploughing out campaign, has risen steadily since the end of the war and in 1955 was estimated at 1·7 million acres. Oats and mixed corn are the principal cereal crops and although the acreage of the former was some 370,000 in 1943, it has dropped steadily since the end of the war and is now estimated at some 160,000 acres, virtually what it was in 1939. Mixed corn continues to drop, although at 60,000 acres it is still more than four times what it was in 1939. Fodder crops, which were at a peak in 1943, show a downward trend in acreage, some 150,000 acres being grown in 1955. On the other hand, there has been a steady increase in silage production, some 146,000 tons being produced in 1955. Holdings are generally small, and out of some 55,000 in the Principality, about 50 per cent. are less than 30 acres in extent.

11. Stock rearing is traditionally the predominant method of utilising the land and because of the large area of rough grazings, permanent flocks of sheep are commonly found. The present sheep population of Wales amounts to about 4·7 million of which some 40 per cent. are hill sheep, mainly of the Welsh Mountain breed, although in some areas (e.g. parts of Brecon) Cheviot blood has been introduced.

12. The cattle population in 1955 was 1·03 million. The Welsh Black predominates in Merioneth and some parts of North Cardiganshire, Caernarvonshire and W. Denbighshire; Herefords and Friesians occur elsewhere

and occasional herds of Shorthorns are found. The lowland and valley farms carry dairy herds, whilst those upland farms which have cattle maintain them mainly for rearing, although it is to be noted that even in a county like Merioneth the majority of the holdings over 5 acres produce milk. The pig population is roughly 240,000 and the poultry flock in 1955 was estimated at 4·8 million, both these types of stock being of less significance on the hill land farms.

IV. GEOLOGY AND SOIL CONDITIONS

13. The parent geological material of Wales is not widely heterogeneous. The central uplands consist mainly of rocks of the Silurian, Ordovician and Cambrian formations and still earlier metamorphic and igneous types occur on the fringe of the central region in Caernarvonshire, East Merioneth, Anglesey and West Pembroke. A wedge of Old Red Sandstone runs in a North-East–South-West direction across Brecon and South Carmarthen finishing in Pembroke and with a spur into Monmouth. This latter county and Glamorgan are largely on the Carboniferous formations which has given rise to the main part of the South Wales Coalfield. There are other rock formations, mainly of local importance, including the alluvial deposits of the Vale of Clwyd and the other larger valleys.

14. Soils in the main are not very diverse although the range is from sandy loams to fairly heavy clays. On the hills the soil is shallow; in the valleys it may be relatively deep. The nature of the parent materials coupled with the heavy rainfall leads to the formation of soils reasonably adequate in potash but with relatively low phosphate, of an acid nature, and generally with a higher organic matter content than most soils in England.

15. Welsh soils are more responsive to phosphate manuring than most English soils and are capable of producing good crop yields under conditions of acidity which in the East and South of England would result in crop failures. The highly leached conditions and the high organic matter content present physical and chemical problems which are further influenced by climatic conditions.

16. Probably not more than 1,400 square miles of the Principality have been surveyed by the Soil Survey of England and Wales, mainly in the lowlands and coastal belt, and no official publication* has yet been issued although memoirs and maps of some parts of North Wales are near to publication.

17. It is our opinion that the classification of soil series together with information on soil structure and the status of the main exchangeable bases would be of great help to N.A.A.S. Soil Chemists in the interpretation of soil analytical data. Rapid extension of the Soil Survey by reconnaissance small-scale mapping which could be completed relatively quickly would be of considerable help to advisory officers and indeed must be regarded as essential to enable advisory officers to carry out their work properly.

18. Lime and phosphate (and possibly potash) are essential for the improvement of hill land which is typically very acid and highly leached.

19. The conventional methods of determination of lime requirements may suggest a higher figure under Welsh hill conditions than may be necessary. For that reason the lime levels as determined by the exchangeable calcium are used and may be a more reliable guide. Since heavy dressings are,

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* Soil Survey of Anglesey has appeared since this report was drafted.

in any case, difficult and expensive to apply in upland areas, there is need for further examination to determine the minimum effective dressings of lime. Some work has been done on aerial top-dressing with ground limestone on Plynlimon and some small areas have been treated with the aid of a machine which blows lime onto the hillside. The Hill Farming Research Organisation has work in hand on the treatment of hill land with various rates of ground limestone (and superphosphate) but only three of the trials are in Wales (rainfall varying from 55 ins.–60 ins.), the others being six sites in England (rainfall varying from 40 ins.–60 ins.) and five sites in Scotland (rainfall varying from 30 ins.–50 ins.).

20. There is clear evidence of the value of heavy dressings of lime in improving yield and quality of herbage. What is not clearly established is the *minimum* dressing which will improve hill land and upland pasture. In this connection the possible importance of trace elements cannot be overlooked. Liming, which is prerequisite at present to successful reclamation, decreases the solubility of some of the trace elements but increases the availability of molybdenum. This element is important for the proper functioning of the root-nodule bacteria associated with clover. It is possible that the failure of clover to maintain itself in hill pasture in the past was due to the lack of available molybdenum through the application of too little lime. In New Zealand very striking effects have been produced by the use of molybdenum and there is some indication already in Wales that a small amount of this element with phosphate gives increased pasture growth on very acid reseeded soils.

21. We conclude on the information we have been able to get that there is a need for investigating further the possibility of using lighter dressings of lime together with small amounts of molybdenum.

22. Under high rainfall conditions phosphate is not leached out to the same extent as lime and it appears to combine with the organic matter in the soil. It is of interest that in East Africa with conditions of high soil organic matter and rainfall, methods of soil analysis used in temperate parts of the world have been found to be of little use in predicting the additional crop yield that would be obtained by adding a phosphate fertiliser and that the phosphate available to herbage and that present in the herbage may be greatly reduced during periods of heavy rainfall. To a lesser degree these things might be expected under Welsh conditions.

23. During our visits to Wales and from the evidence submitted the increasing importance of hypomagnesaemia in stock was impressed upon us. While we gained the impression that this metabolic disorder may be due to a complex of factors (see section on *Animal Health*), the importance of magnesium is accepted. The N.A.A.S. has started an investigation into the seasonal variation of the magnesium content of lowland grazings. The early results of this work indicate a very significant decrease in the mean magnesium (and calcium) content of herbage in April as compared with October. There appears to be need for further systematic investigations of this sort in relation to geological formations and soil series.

24. The trace elements cobalt and copper are also of importance in connection with animal health on both unimproved and improved hill lands. Improvement of crop and herbage production per acre increases the drain on available trace elements. While the evidence suggests that copper is

not generally a limiting factor for crop and herbage growth in Welsh soils, fairly low values for the copper content of herbage are often recorded and we suggest the need for work on the possible exhaustion of this element from the surface to root-depth layer of the soil by improved swards.

25. In general we consider that the minimum lime, other mineral, and trace element requirements necessary for the improvement of hill land under high rainfall conditions, coupled with the loss of plant foods in drainage and run-off, constitute important problems in Wales. The fact that satisfactory crops may be grown in Wales at lower pH values than elsewhere is accepted but it cannot be regarded as satisfactory that the reasons for this are not clearly understood. Although aspects of these problems are under investigation elsewhere, the results of such work may not be fully applicable to Wales because of conditions of weather and soil.

V. DRAINAGE

26. Drainage of hill (and lowland) is a problem in some areas in Wales, the importance of which can be further seriously aggravated by the incidence of Liver Fluke disease (see section on *Animal Health*). Open gripping is practised on those hill areas which are relatively free from stones. There are problems on the intermediate land which are similar to those encountered on similar land in England but the high rainfall adds to the difficulties.

27. There appears to be no precise information on the effectiveness of different depths and spacings of open grips or pipe drains, nor on the most desirable drainage conditions from the husbandry point of view. We were informed that decisions on the actual alignment and closeness of the cuts on hill draining were frequently left to the tractor driver's experience and judgment. The difficulties of drainage investigations are well-known but, in spite of these, we think it important to try to obtain better information on drainage layouts.

28. It is evident that there is still uncertainty about the rate at which water is drawn off by various systems of drainage. In addition, the effects of soil moisture on the growth of cotton grass or draw moss (*Eriophorum*) and on the snail, which is the intermediate host of Liver Fluke, are not known.

VI. MACHINERY

29. Machinery problems were seldom mentioned to us. A Working Party set up by the N.A.A.S. in Wales in 1947 reported to the Agricultural Improvement Council for England and Wales in June 1950 and the Welsh Agricultural Land Sub-Commission Report on the Mid-Wales Investigation (Cmd. 9631, Dec. 1955) also commented on the special needs of the Principality.

30. The latest information on the problems of Welsh Hill Farm Mechanisation is contained in a survey by the Special Survey Section of the N.I.A.E. in Mid-Wales. (A Survey of Welsh Hill Farm Mechanisation: J. K. W. Slater and M. P. Jones, J. Agric. Engng. Res. *2* No. 3, 1957.) This paper contains, amongst others, the following conclusions:—

(*a*) With the exception of haulage, the Welsh hill farmers in the Survey area can carry out satisfactorily the necessary farming operations with their existing equipment under the present farming system.

(*b*) The problem of haulage requires investigation and some consideration should be given to methods of overcoming the difficulties met under hill farming conditions. This problem is almost certainly common to most hill farms and the potential market is therefore a reasonably attractive one.

(*c*) The continued use of the old, traditional hay making methods indicates that some thought should be given to alternatives especially those developed for use in the wetter areas.

31. The inference from the N.I.A.E. Survey is clearly that attention should be given to haulage problems of hill land farms and it is to be hoped that N.I.A.E. will be able to take action.

VII. GRASSLAND

32. The improvement of hill grassland is mainly brought about by the following methods depending on the nature of the terrain:—

(*a*) Improvement by the surface application of lime and fertilisers.

(*b*) Surface cultivation followed by lime and fertilisers and sowing with grass.

(*c*) Ploughing for a pioneer crop and reseeding.

33. The strains of grasses used are those which have been developed for lowland conditions and very simple seeds mixtures are generally used. The problems associated with the requirements for and the application of plant foods have already been mentioned in the section on *Soil Conditions.*

34. We were told on numerous occasions that whilst there were problems of animal health on unimproved grassland such troubles were greatly accentuated as soon as swards were improved. There appeared to be a complex of beliefs about how grassland improvement led to stock disorders. Thus we had statements that the improved strains of grasses were responsible, or that seeds mixtures were too simple compared with what they used to be, or that the intensive use of nitrogenous fertilisers leads to increased growth which rapidly exhausts the soil of trace elements. It might well be that the problem is a complex of these things coupled with the heavier stocking of improved land.

35. We have come to the conclusion that the improvement of grassland cannot be assessed only in terms of increased production of herbage but that it must be related to its quality and to its effect on animal health. Consequently there is need for a study of the effect of different strains of grasses, both singly and in mixtures, on animal nutrition and health especially in high rainfall areas. The development of improved strains of indigenous hill land grasses merits attention to see whether they give better results on the hill than the improved lowland strains. Cattle and sheep and even their different breeds, may not be affected in the same way by variations in herbage. Such studies should be in collaboration with the soil and nutrition chemists and the veterinary experts.

VIII. ANIMAL NUTRITION AND STOCK MANAGEMENT

36. Wales is predominantly concerned with stock rearing and the problems of animal nutrition rank high in importance. The uplands exhibit a wide range of vegetative cover leading to notable differences in botanical composition with a consequent effect on the nutritive value of the sward and the

stock carrying capacity. The management of hill sheep flocks follows a fairly set pattern. The ewes are brought down to the ffridd or intake land for tupping in late October or early November. Such land may be improved, is generally fenced, but may not be extensive. After tupping the ewes move back to the higher land where they stay to December or January depending on weather conditions, after which they come down again to the ffridd, staying there until early May after lambing. Ewe lambs and barren ewes may be wintered at home if there is sufficient bottom land pasture but are more often agisted returning to the mountain in April. Wether lambs are generally not kept to the yearling state, being sold off fat or as stores.

37. Much is known of the value of "early bite" but little factual information is available on the nutritional value of grass in late summer and autumn. Those areas which have a high rainfall in summer tend to have very lush growth of grass but in spite of the abundance of herbage neither sheep nor cattle thrive as well as they do on sparser pasture. Reference has already been made to the possible exhaustion of certain trace elements from the soil but the "wateriness" of the herbage may be an additional component in the complex of nutrition and animal health.

38. Hay is the mainstay of winter feeding in Wales and its quality can be seriously affected by weather conditions at harvest time. The addition of supplements based on analysis of the hay does not always give the results expected. Although the N.I.A.E. is examining better methods of haymaking under high rainfall conditions, the problem of quality in hay cannot be completely solved solely by calculation of the theoretical energy levels. There is a need for digestibility trials.

39. Where silage is made there is a need for an investigation of the nutritional value of the product made at different times of the year and especially in autumn, since the moisture content of grass and other crops is generally higher than in the drier parts of the country.

40. The use of crops like kale and the winter grazing of rye were noted. In the case of the former crop we conclude that there is a need for more information on the time of sowing, fertiliser requirements, time of availability and yield of the crop.

41. The changes in diet consequent on the movement of sheep from the mountain to the ffridd, i.e. from the unimproved grazing to the improved and vice-versa, and in cattle as a result of the change from winter to spring feeding is known to occasion metabolic disorders. These will be referred to again the section on *Animal Health*.

42. Wintering away of ewe lambs is necessary on many farms where there is difficulty in maintaining the whole flock at home because of the shortage of improved lower land and the problem of winter keep. Apart from considerations of cost which are of first importance, more information is required on the effects of supplementary feeding and of wintering ewe lambs in hogg houses particularly in respect of loss of condition, acclimatisation to the hill after the winter, and fertility when the animals join the breeding flock.

43. In general, we consider that the soil and climatic conditions in Wales have a considerable, but very imperfectly understood, effect on the feeding value of grass and crops either conserved or not. It has been strongly represented to us that in this, as in other animal nutrition problems mentioned

above, effective progress is not to be expected until a much better knowledge of ruminant digestion has been gained. We find that responsible opinion is convinced that there are repercussions on the animal health side which require investigation.

IX. BRACKEN

44. The problem of bracken was brought to our attention several times. Estimates made by N.A.A.S. Grassland Officers in 1956 showed that some 144,000 acres of land (exclusive of common land) were infested in Wales of which just over 74,000 acres was land difficult to improve because of the terrain, 45,000 acres were intermediate land, and 25,000 acres consisted of land that was accessible and ploughable. There was no evidence of bracken spreading in Wales on a significant scale and indeed contraction of the infested area was said to be occurring in parts of Wales, possibly through the use of Marginal Production and Ploughing Grants. The intermediate land is usually tackled by cutting and bruising techniques whilst the difficult land would require really expensive methods as alternatives to afforestation.

45. Bracken land is probably the most economic to reclaim if it is ploughable since it is generally dry and does not revert quickly to *Agrostis.* There is evidence that there are herbicides that have an effect on bracken and the A.R.C. Unit of Experimental Agronomy has a number of trials all over the country of which two are in Wales but at a comparatively low level. A " disease " which suppresses bracken on small isolated areas has been noted in Wales and some attention is being given to it.

46. Bracken poisoning is under investigation at the University College of North Wales. We conclude that the bracken problem is receiving close attention on those fronts where it is thought progress may be made.

X. ANIMAL BREEDING

47. The difficult question of what constitutes hardiness in sheep was raised several times. Flock societies are very interested and there is work in progress at Aberystwyth, Bangor and elsewhere. Hardiness in hill sheep, which is the ability to thrive in their rigorous environment, is a complex of factors. We feel that the scope and objectives of present work should be reviewed.

XI. ANIMAL HEALTH

48. The problems most frequently brought to our attention were those concerned with animal health. In the main the important diseases are not specific to Wales and some of them such as bloat, Johne's disease, the various forms of abortion in cattle, pig pneumonia and poultry disorders seem not to have a higher incidence in Wales than in other parts of the country and we heard no statements contrary to this conclusion.

49. On the other hand we became convinced that there were certain metabolic disorders and certain diseases due to parasites which were present to an extent which made them a severe handicap to farming in the Principality. It seems probable that this greater incidence is largely due to the very high stock population and the climatic and environmental conditions. It is, we think, clear that animal health problems cannot be considered in isolation from these other factors.

50. We have not found it possible always to get quantitative evidence of the gravity of problems either from the veterinary profession, the Veterinary Investigation Officers, the N.A.A.S. or farmers, because of the difficulties of keeping records or accurately diagnosing the primary cause of mortality, and surveys appear to be difficult to carry out in some cases.

51. On unimproved hills, ewes have a minimal nutritional intake when their nutritional needs are at a peak and pregnancy toxaemia (twin lamb disease) is common in some years. Effective work on this is in progress at Oxford. The transfer of flocks from the mountain to the improved ffridd may be followed by a high incidence of metabolic disorders and anaerobic infections. Farming opinion is in no doubt that the improvement of hill grazings is followed by the appearance of disorders which were hitherto regarded as being confined to lowland sheep, and this view has much support in Veterinary circles.

52. Hypomagnesaemia was stated to be much more prevalent than in the past on both hill and lowland grazings and although we have not been able to obtain quantitative data of the increase of this and related disorders it would appear that the problem is important in Wales. We understand that hypomagnesaemia in sheep has been attracting increased attention elsewhere in the country and that more research is considered to be necessary.

53. There is also the probability that hypomagnesaemia and hypocalcaemia may occur together and there is evidence from general veterinary practice and from the preliminary work of the N.A.A.S. Nutrition Chemist and the V.I.O. in Brecon in 1957, that calcium-magnesium borogluconate injections to affected sheep have given good results. Mineral analyses of herbage have indicated sharp seasonal difference in the calcium and magnesium content (para. 23) and an attempt is being made to correlate these with blood levels of the elements.

54. Reference was made earlier to the great importance of calcium (and phosphorus) for the improvement of grassland, emphasis being laid on the problem of applying the requirements of lime indicated by conventional analysis. The work of Professor R. O. Davies and Mr. W. J. Milton over the past thirty years has shown that herbage from limed plots differed little in protein or energy content from that of unlimed plots, but the calcium content was greatly increased. Subsequently it was shown that hay from unfertilised and unlimed plots fed to sheep with the addition of calcium carbonate gave the expected improved nutritional value.

55. We suggest that it would be worthwhile examining the extent to which it is feasible to use light dressings of lime on hill land while supplying the grazing animal with minerals in an attempt to prevent metabolic disorders and that this suggestion be considered in conjunction with the one for investigating the possibility of using light dressings of lime and trace elements for improving hill swards (para. 21).

56. It appears to us that the knowledge of the causes of hypomagnesaemia is so incomplete as to make it impossible to give sound advice to farmers. We are of the opinion that the problem requires an attack on several fronts and that the work in hand elsewhere in the country and that described in para. 53 should if possible be supplemented by further work of a similar nature in Wales.

57. Anaerobic infections, amongst which enterotoxaemia was particularly mentioned, were stated to be serious problems. We understand that the bacteriology of the condition is fairly well known but that the emphasis in further investigations should be on the nutrition and husbandry sides. This view shows the need for co-operation between a number of specialists and for carrying out some of the work in the environment where the problem is particularly important.

58. Animal health problems connected with deficiencies of trace elements such as cobalt and copper were brought to our attention and appear to be locally important but we understand that they are certainly less prevalent than in some other parts of Great Britain.

59. We were told of low lambing percentages. A recent economic survey of sixty-five hill flocks for the years 1954–55 and 1955–56 covering flocks ranging from less than 200 to over 800 breeding ewes showed lambing percentages ranging from 80 per cent. to 95 per cent. with weaning percentages ranging from 57 per cent. to 87 per cent. The tendency appears to be for the larger flocks to have a lower lambing percentage and to suffer a greater mortality of lambs. Another survey conducted by the N.A.A.S. on the 1956 lamb crop covered 638 flocks with an average number of 278 ewes per flock. Out of 177,000 ewes mated some 2·9 per cent. died during pregnancy, the total lambing percentage being 85·1 per cent. and barren ewes amounting to 9·8 per cent. Ewe deaths after lambing amounted to 2·2 per cent. and lambs at the summer count totalled 81·7 per cent. of the ewes mated. The range of lambing percentages was from 76 per cent. on high farms where no supplementary feeding was practised to 87 per cent. on kinder farms. It is clear that there is a wide range of lambing percentage, that barren ewes and young lamb mortality are mainly responsible and that there is a problem here which requires attention.

60. Two sheep diseases which cause great losses in sheep in Wales are Liver Fluke and Black Disease (*necrotic hepatitis*).

61. Acute Liver Fluke infestation periodically causes heavy losses to sheep in the late autumn while the debilitating effects of chronic infestation are very well known. The acute condition which results from a very heavy infestation by immature flukes does not respond to the standard treatments with carbon tetrachloride or hexachlorethane which will prevent deaths from the chronic form of the infestation.

62. The only satisfactory way of controlling Liver Fluke disease is to prevent the infection from reaching the animal. This can be achieved by stopping access to flukey areas by removal of stock, or fencing; by treating infection areas with molluscicides to kill the snail intermediate host, or by draining the areas where the snails live and so permanently killing them off.

63. Keeping stock away from infection areas and the use of molluscicides are temporary palliatives, and we heard statements that copper sulphate treatment appears not to be as effective in killing snails as hitherto. This probably reflects the short-term action of copper sulphate. Additionally there may be a reluctance on the part of farmers to apply an annual treatment when they are aware that heavy mortality of sheep does not occur every year.

64. It would therefore appear that drainage of infection areas offers the most permanent solution to the problem. The difficulties of drainage have already been referred to and the extent of the drainage and therefore the fluke problem in relation to Liver Fluke varies as between the hill and lowland farms. On lowland farms the areas requiring drainage may be extensive or in patches depending on topography, soil type and season. On hill farms the infection areas tend to be restricted to points where springs reach the surface. At such points the water has a relatively high concentration of salts which are essential for the snail and which lead to the growth of flush vegetation.

65. Eradication of all flush areas on a farm would be a great task and would also affect the amount of grazing available since flushes provide some of the "early bite" in Spring. Yet careful management of flushes might increase the amount of herbage whilst reducing the risks of fluke.

66. It would seem that drainage is likely to be most beneficial on the lowland farm. Dr. Ollerenshaw of the Veterinary Laboratory, Weybridge, has compared the copper sulphate treatment with drainage on a Welsh lowland farm and the long-term beneficial effects of the latter were abundantly demonstrated with respect both to snail population and to fluke population within the snail; and there is similar evidence from a Scottish hill farm.

67. We are impressed by the interesting scientific accounts of fluke which have been written but the incidence of the disease does not appear to be lessening and it needs first-class husbandry to hold infection in check.

68. It is our opinion that the feasibility of establishing fluke-free lowland areas should be examined and that work on hill land should be extended. It seems to us that although the difficulties of drainage are great, the achievement of such areas would greatly reduce losses from Liver Fluke in Wales and could be of very great value in raising the standards and reputation of those areas which export stock to other parts of the country.

69. While reference has been made principally to sheep, the Liver Fluke problem is also very serious in cattle and we were told of a survey of the incidence of the disease in South Wales where 70 per cent. of the livers of cattle sent for slaughter were found to be damaged.

70. The tables in Appendix II give a clear indication of the importance of Liver Fluke (and other diseases in sheep) in Anglesey and some of the other Northern Counties of Wales. These figures probably reflect another aspect of the movement of sheep from one environment to another. In this case hill sheep are drafted in from the mountains for fat lamb production. The ewes come in at a critical time so far as general condition is concerned and it is in these that the heaviest mortality through Liver Fluke occurs. Black disease—an anaerobic bacterial infection superimposed on Liver Fluke infestation—is also responsible for notable losses. Amongst other diseases reported to us to be prevalent or difficult to deal with were, husk, parasitic gastro-enteritis, anoestrus, bovine piroplasmosis, enzootic haematuria, haemoglobinuria in cattle and *Nematodiriasis* in sheep.

71. We have already mentioned the difficulties we met in obtaining accurate statistics of the incidence of animal health problems (Para. 50) and Appendix II gives the only figures we were able to obtain. We suggest that

the survey method is the one most likely to put the various animal health problems in the right perspective, so indicating to the research worker where most effort is required.

72. It would seem to us that many of the problems appear to be an expression of the interaction of land improvement techniques and animal husbandry and that progress will best be made by the specialists in all these fields joining together in a co-operative effort. The part played by environmental conditions must not be overlooked and some of the field work must be done in the areas where the problems occur.

XII. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

73.—(1) The classification of soil series together with information on soil structure and the status of the main exchangeable bases would be of great help to N.A.A.S. soil chemists in interpreting soil analytical data. Extension of the Soil Survey, perhaps by reconnaissance small scale mapping which could be completed relatively quickly, could be of considerable help to advisory officers. (Paragraphs 16, 17.)

(2) The minimum lime, other mineral and trace element requirements, necessary for the improvement of hill land under high rainfall conditions, coupled with the loss of plant foods in drainage and run-off, constitute an important technical question in Wales and although some aspects of it are under investigation elsewhere, the results of such work may not be fully applicable to Wales because of conditions of weather and soil. (Paragraphs 18–25.)

(3) Manurial requirements of crops and grass in areas with more than 40 ins. or so of rainfall have not been adequately determined nor has effective knowledge been gained of their relationship to pH and other soil characteristics under these conditions. (Paragraphs 22, 25.)

(4) There appears to be no precise information on the effectiveness of different depths and spacings of open gripping and other types of draining. The difficulties of drainage investigations are appreciated but in spite of these we think it important to obtain better information on this matter. (Paragraphs 26–28.)

(5) There seems to be a need for improved haulage machinery but this is common to all hill land. The authors of a recent N.I.A.E. paper have made specific suggestions for work. (Paragraphs 29–31.)

(6) The improvement of grassland cannot be assessed only in terms of increased production of herbage ; it must be related to the quality of that herbage and its effect on animal health. Consequently there is need for a study of the effect of different strains of grasses both singly and in mixtures on animal nutrition and health. The development of improved strains of indigenous hill land grasses merits attention to see whether they give better results on the hill than the improved lowland strains. (Paragraphs 32–35.)

(7) There is a need for more information on the nutritive value of grass in late summer and autumn, of silage made at different times of the year, on the best time of sowing, the fertiliser treatment and the availability of crops that provide winter keep. (Paragraphs 36–43.)

(8) As part of the problem of metabolic diseases the effect of the movement of stock from unimproved to improved grazings should be examined. (Paragraph 41.)

(9) Studies of alternative methods of wintering sheep in relation to the winter keep problem are worthy of investigation. (Paragraph 42.)

(10) The problem of bracken is considerable but it is believed that its solution is being attempted wherever it is thought progress might be made. (Paragraphs 44–46.)

(11) The scope of the breeding work in relation to hardiness in sheep should be reviewed. (Paragraph 47.)

(12) Metabolic disorders such as hypomagnesaemia appears to be causing increasing trouble and the solution of these problems requires more effort. Since such troubles seem to occur in connection with the improvement of grazings, a co-operative effort appears to be required by all the specialists concerned in the improvement of land and the treatment of disease and the solution of these problems will best be sought in the environment in which they occur. (Paragraphs 48–58.)

(13) Low lambing rates in hill flocks give cause for concern and an examination of the problem is necessary. (Paragraph 59.)

(14) Liver Fluke (and subsequently Black Disease) cause very heavy mortality in sheep and Liver Fluke is also a considerable problem in cattle. Drainage of land offers the best remedy and some efforts should be made to free circumscribed areas from the snail alternate host of this parasite. (Paragraphs 60–70.)

(15) There is a lack of precise information on the incidence of animal diseases and some are believed to be much more common than a few years ago. Surveys of incidence should be made where techniques for these are available. The results would show the relative importance of the chief diseases thus indicating where the available research effort should be applied. (Paragraphs 71, 72.)

(Sgd.) F. L. ENGLEDOW (*Chairman*).
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E. GIBBY.
T. E. GWILLIM.
T. H. JONES.
E. J. ROBERTS.
A. R. WANNOP.

M. COHEN
R. A. HUGHES } *Joint Secretaries.*

APPENDIX I

LIST OF WITNESSES AND EVIDENCE RECEIVED

1. *The Ministry of Agriculture, Fisheries and Food*

Welsh Secretary	Oral Evidence
Mr. E. Ll. Harry (late Director N.A.A.S., Wales)	Written and Oral Evidence
Mr. W. E. Jones (Director N.A.A.S., Wales)	Oral Evidence
Regional Specialists (N.A.A.S.)	Written and Oral Evidence
Mr. A. G. Beynon (S.V.O., Wales)	Oral Evidence
Mr. H. I. Field (Veterinary Investigation Service)	Written and Oral Evidence
Major E. S. Dobb (Deputy Director, Agricultural Land Service)	Written and Oral Evidence
Mr. E. A. G. Johnson Mr. C. H. A. Duke } Land Drainage and Water Supplies Division	Oral Evidence

2. *Welsh Organisations*

Royal Welsh Agricultural Society	Written and Oral Evidence
Welsh Agricultural Organisation Society	Written and Oral Evidence
British Veterinary Association (Welsh Branch)	Written and Oral Evidence
Farmers Union of Wales	Written Evidence
Anglesey A.E.C.	Written Evidence

3. *Universities*

University College of North Wales, Bangor	Written and Oral Evidence
University College of Wales, Aberystwyth	Oral Evidence
Guild of Graduates, University of Wales	Written and Oral Evidence

4. *Others*

Dr. Richard Phillips (Minister's Liaison Officer)	Oral Evidence
Mr. Moses Griffiths (with W.A.O.S.)	Written and Oral Evidence
National Institute of Agricultural Engineering	Written Evidence
National Farmers Union for England and Wales	Written and Oral Evidence

5. *Farmers* (Oral Evidence only)

Capt. G. L. Bennett-Evans, M.B.E., Llangurig, Montgomeryshire.
Mr. H. J. Griffith, Wig, Aber, Caernarvonshire.
Mr. Trevor Lloyd, Anglesey.
Mr. Edward Jones, Corwen, Merionethshire.
Major J. R. P. Jeffreys, Sennybridge, Breconshire.
Mr. Ll. Richards, Sennybridge, Breconshire.

6. *Farms Visited*

The Committee visited the following farms during their tours of Wales and were accompanied by the County Advisory Officers.

Mr. T. E. Jones (Dairy Farmer), Llanfyllin, Montgomeryshire.
Mr. J. L. Hughes (Mixed Farming), Llandrinio, Montgomeryshire.
Mr. Dafydd Jones (Sheep Farmer), Llangadfan, Montgomeryshire.
Mr. M. Jones-Griffiths (Hill Farmer), Natyfyda, Montgomeryshire.
Mrs. Esme Firbank (Hill Farmer), Snowdonia.
Mr. Frank Griffith (Hill Farmer), Crug, Caernarvonshire.
Mr. W. T. Jones (Dairy Farmer), Anglesey.
Mr. D. West (Hill Farmer), Cray, Breconshire.
Mr. D. R. Thomas (Lowland Farmer), Llandilo, Carmarthenshire.
Mr. Tom Evans (Stockbreeder), Brongest, Cardiganshire.
Mr. W. Evans (Marginal Land), Talgarreg, Banc Shon Cwilt area, Cardiganshire.

7. *Official Stations visited*

Welsh Plant Breeding Station, Aberystwyth (Director, Professor E. T. Jones).
Trawscoed Experimental Husbandry Farm (Director, Mr. W. M. R. Evans).
Pwllpeiran Experimental Husbandry Farm (Director, Mr. M. Roberts).

APPENDIX II

I. EWE LOSSES IN ANGLESEY

(*1st October* 1954 *to* 31*st March* 1955)

From data provided by the survey, it is shown that 15·5 per cent of the total ewe stock died between 1st October 1954 and 31st March 1955.

On the basis of the 4th June (1954) returns, this represents 14,000 (approx.) ewes (i.e. 15·5 per cent of 90,000 (approx.) ewes).

The cause of these losses based on post-mortem results of 274 ewes received from Anglesey in the same period Table 1 are set out in Table 2 as a percentage and total figure and as an estimated financial loss based on the value of the ewe at £7 (Llangefni—June).

TABLE 1

Diagnosis	Cases	Percentage
Fluke	107	40
Enterotoxaemia	65	23
Metabolic	60	21
Black Disease	18	6·5
Miscellaneous	19	7·0
No diagnosis	5	2·5
Totals	274	100

TABLE 2

Cause	Percentage	Total	Financial loss at £7 per ewe
Fluke	40	5,600	39,200
Enterotoxaemia	23	3,220	22,540
Metabolic	21	2,940	20,580
Black Disease	6·5	910	6,370
Miscellaneous	7·0	980	6,860
No diagnosis	2·5	350	2,450
Totals	100	14,000	98,000

II. SHEEP LOSSES OCTOBER 1954–MARCH 1955

County	Ewes at Risk	Percentage Losses	Numbers Lost
Anglesey	81,000	15·5	14,000
Caernarvonshire	214,000	6·0	12,000
Denbighshire	232,000	7·3	16,900
Flintshire	41,000	10·4	4,260
Merionethshire	294,000	5·5	16,170
Total	861,000	7·3	63,330

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